ENVIROSCIENCE

November 14, 1983

TO: Ken Sullivan

FROM: Vic Kalcevic

SUBJECT: Work Plan for Cyanide Contaminated X-Ray Film Decontamination Study

Erclosed is the work plan for doing the proposed laboratory and process ergineering work on the cyanide contaminated x-ray film problem in Region V of the USEPA. IT-Knoxville is prepared to move rapidly to implement the plan when approved.

If you have questions, please call either Charles Parmele or myself.

aab

Enclosure

cc: T. Dehnke, M. O'Toole, C. Parmele, C. Stuewe

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Division of IT Corporation

ENVIROSCIENCE

EERU WORK PLAN

CYANIDE CONTAMINATED X-RAY FILM DECONTAMINATION STUDY

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D129-EERU

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I. INTRODUCTION

This project will involve conducting laboratory bench-scale testing and preliminary process engineering to evaluate a method to decontaminate spent x-ray film left from a defunct silver recovery operation. Film Recovery Systems, Inc. was extracting silver from old x-ray negatives by using a cyanide bath process. There are still 4.5 million pounds of cyanide-contaminated film in ~150 semi-trailer vans located at several sites in the Chicago area and ~10 million pounds in a warehouse in Dixon, Illinois. This cyanide-contaminated spent film is in chip form, with ~99% in postage stamp size and shape, and can be either wet or dry depending on how it has weathered in storage. Also, an appreciable amount of extraneous material such as other film products, dirt, wood, etc. is mixed in with the contaminated film.

This contaminated film problem came to the attention of local environmental authorities in the spring of 1983. In June 1983 the Weston-Sper Technical Assistance Team conducted a brief treatability study for U.S. EPA Region V and proposed that the conventional cyanide oxidation with sodium hypochloride treatment would be feasible to decontaminate the film. This method was implemented by Petrochem, Inc. and used to treat 1.5 million pounds of film in the field for the Illinois EPA. This operation had field operating and materials handling problems that caused a cost overrun, so it was shut down. Also, there is some evidence that the cyanide destruction was incomplete because the cyanide was trapped in the gel emulsion and was not amenable to oxidation.

In August 1983 the ITT Research Institute completed an engineering and market study for the State of Illinois Attorney General that examined the potential market for detoxified film chips and evaluated the various treatment or destruction processes proposed for handling the contamination problem. The conclusions were: that there is no firm market for the detoxified chips, that proper incineration of the chips appears quite feasible, and that chemical decontamination can be eliminated on the basis of cost.

The objective of this study is to examine the key operating variables for the chemical decontamination of the film at the laboratory bench scale and to use these data in a preliminary process design and cost evaluation. U.S. EPA Region V will have a parallel study done on incineration of the contaminated film.

II. PROJECT SCOPE AND TECHNICAL APPROACH

The scope of this project is limited to:

- Evaluating in bench-scale laboratory equipment the various important operating parameters for a two-step chemical destruction process consisting of:
  - Extraction of the contaminated film with hot caustic solutions
  - Destruction of the cyanide in the extract by oxidation
- A preliminary process design and cost estimate for a conceptualized process based on the above data for comparison to the alternate treatment by incineration or proposed proprietary processes.

A. PART A - LABORATORY BENCH-SCALE TESTS

The objective of the laboratory testing is to evaluate the technical and economic feasibility of this process by evaluating the following issues:

- Effectiveness of the extration step
- Optimum composition of the extract
- Mixing characteristics of the film chips
- Effectiveness of chlorination for oxidizing cyanides
- Oxidant consumption to oxidize other constituents as well as cyanides
- Composition of oxidized effluent including presence of chlorinated by-products and heavy metals

The objective will be met by performing <u>separate</u> laboratory tests of the extraction step and the cyanide oxidation step. However, before any tests are conducted, the samples of wet and dry chips will be independently blended thoroughly to provide a consistent starting material for each extraction test.

Initial laboratory tests of the extraction will be performed to evaluate the effects of caustic concentration, temperature, mixing requirements, ratio of extract volume to weight of chips, and agitation time on the removal of cyanides from the chips. Concurrently additional information will be sought from Kodak regarding the optimum conditions for removing the emulsion from film; from the Metropolitan Sanitary District regarding the effluent criteria for cyanides, cyanates, residual chlorine, and other relevant parameters; and from appropriate agencies and disposal facilities regarding the criteria for landfilling the decontaminated chips. Based on the available information the initial set of

experimental conditions will be selected to give the best chance of success as well as to develop sound technical data.

The mixing equipment that will be used will be a baffled, jacketed reactor equipped with a variable-speed agitator. Elevated temperatures will be maintained via automatic temperature control. During the extraction experiments, the mixing characteristics of the chips and the ease with which they can be separated from the extract will be observed. If satisfactory results are not achieved with this equipment, a high-shear agitator will be tested.

During an extraction experiment, samples of the extract will be withdrawn and analyzed for cyanide, total organic carbon, and other relevant species. These data will help define optimum extraction times and the effectiveness of the extraction. The extracted chips will also be analyzed for cyanide to verify the effectiveness of the extraction.

The feasibility testing of the oxidation step will be performed in IT's chemical oxidation miniplant as soon as a sample of extract representative of the optimized or nearly optimized extraction step is available. Overlapping the testing of the two steps will help compress the schedule and develop a timely solution to this problem. The oxidation miniplant is a prototype system patterned after a full-scale chemical oxidation system that was designed, constructed, and operated by IT persononel. It consists of an agitated vessel with a recirculation loop to provide cooling or heating as needed, and measurement of pH and oxidant concentration. The miniplant can be operated like a bleach plant in which gaseous chlorine is dissolved in a recirculating solution of caustic. Alternatively oxidants in liquid form such as bleach or hydrogen peroxide can also be used. Provisions have also been made to catalyze the reactions with UV light. Before any oxidations are run, a sample of the extract will be titrated with a mild oxidizing agent such as standardized hydrogen peroxide to measure the amount of thiosulfate that may be present.

Initial oxidation tests will be run batchwise using bleach to define the reaction kinetics and stoichiometry. It will be important to evaluate the effect of other organics present in the extract on the rate of reaction, chlorine unit ratio, and the effluent composition. During these tests the pH will be moni-

tored continuously. Samples will be periodically withdrawn, quenched immediately with sodium sulfite, and analyzed for cyanide, cyanate, and TOC. Parameters that will be evaluated include temperature, pH, chlorine concentration, and chlorine consumption and residence time. UV catalysis and other oxidants may also be evaluated if preliminary testing indicates that either is a desirable alternate.

B. PART B - PRELIMINARY PROCESS DESIGN

The results will be interpreted using standard chemical engineering reaction kinetics techniques to define the optimum reaction kinetics and stoichiometry. These techniques will provide the basis for developing and evaluating full-scale system designs including batch or continuous processes using bleach, chlorine, or hydrogen peroxide (if tested) as the source of oxidant. The option of combining the extraction and oxidation steps will be compared to performing these steps separately. If necessary the laboratory equipment can be used as a prototype to verify the design of the full-scale system.

A preliminary process flow diagram(s) will be prepared for a conceptualized process(es) to chemically decontaminate the film. This will be based on the laboratory data obtained and on a consideration of the past field operating experience. Special attention will be given to the material location and its handling and transportation problem to the processing step site. A preliminary capital cost estimate, ±30%, and a preliminary operating cost estimate will be prepared for the conceptualized process.

III. PROJECT MANAGEMENT AND REPORTING

The IT Corporation (ITC) Project Manager, Vic Kalcevic, will maintain contact with both the OHMS project officer, Royal Nadeau, and the U.S. EPA Region V official, Mike O'Toole, as required to keep them closely informed about the task progress. Since this task is expected to be completed in a short time period, monthly reports will not be appropriate but weekly reports on time expended will be made to the U.S. EPA-ERT. Upon completion of the laboratory and preliminary engineering work, a report will be prepared and submitted that will include the laboratory findings, its preliminary process design, and the preliminary cost estimate.

IV. PROJECT SCHEDULE, MANPOWER, AND COST

A proposed project schedule is shown in Fig. 1. It is expected that a draft report on the work performed will be submitted to the U.S. EPA for review at the end of December 1983.

A summary of the estimated work effort required and the estimated cost is shown in Table 1. The work will be performed by IT-Knoxville under the Project Manager, Vic Kalcevic, with Charles Parmele having direct responsibility for the laboratory testing.

This level of effort is based on the current understanding of the project. No contingencies have been built into this estimate to deal with unknown factors. For example, no provisions have been made for testing of any post oxidation treatment steps that may be required to remove heavy metals, residual chlorine, or chlorinated by-products. If post oxidation treatment steps are required to remove residual chlorine and/or chlorinated by-products, it may be desirable to substitute UV-catalyzed hydrogen peroxide as the oxidant in the oxidation step. These issues cannot be resolved without additional information.

WORK PLAN APPROVAL

EERU is authorized to implement the above plan.

Signature _____

Title _____

Date _____

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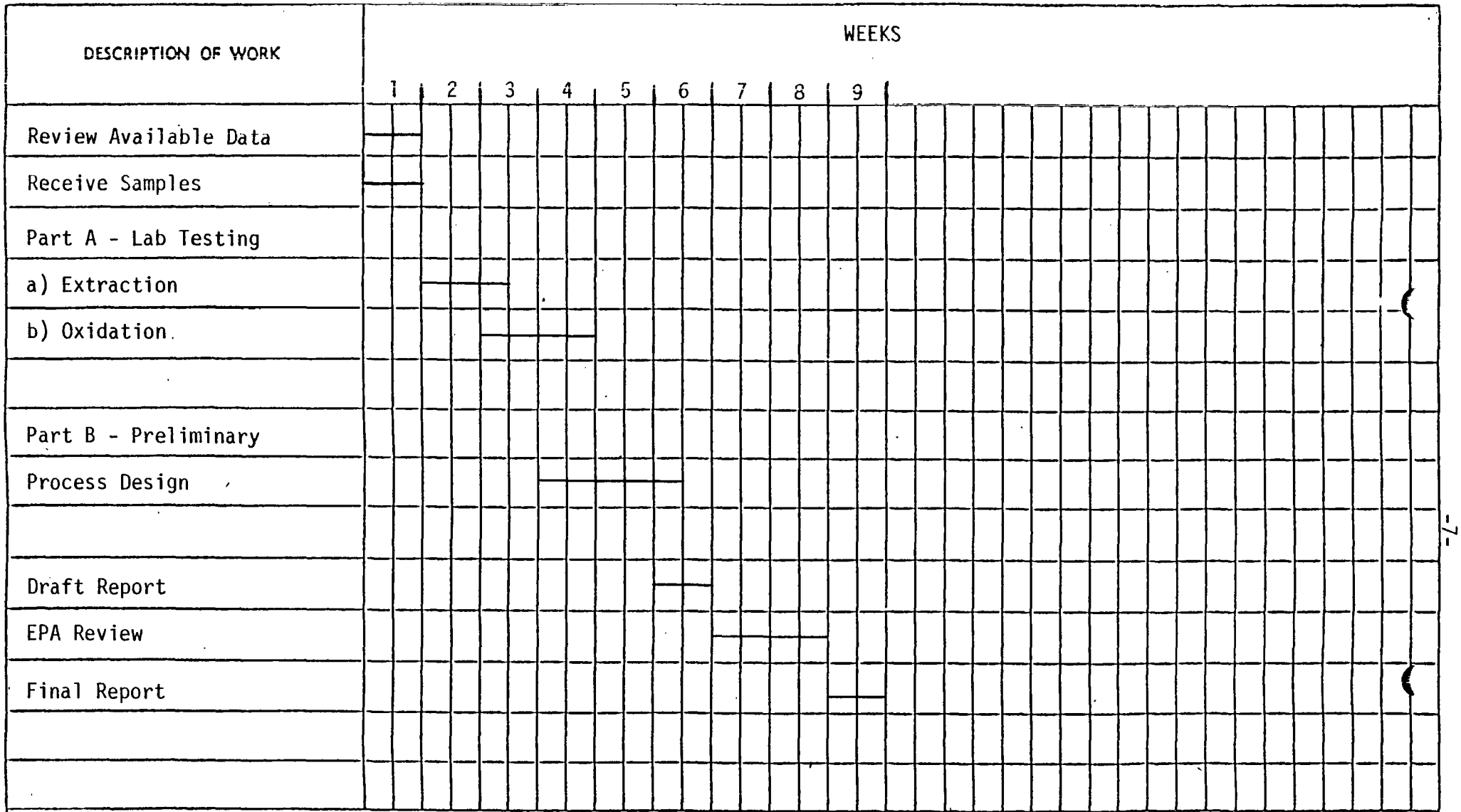

REMARKS:

MADE BY: C. S. Parmele

DATE: 11/14/83

LAST REV. DATE:

Figure 1

PROJECT SCHEDULE

FOR: CYANIDE CONTAMINATED X-RAY FILM DECONTAMINATION STUDY

JOB NO.

SHEET OF

Table 1. Cost Estimate for Cyanide Contaminated X-Ray Film Decontamination Study

	Hrs	Estimate Cost ($)[a]	Total ($)
Prcject Management, Planning, Reporting			
Senior Project Engineer	100		
Engineering Manager	40		
Technical Editor	10		
Direct Costs		300	
Laboratory Study			
Engineering Manager	40		
Engineer I	120		
Direct Costs - CN analyses - 10 chips @ $65 ea.		650	
70 aqueous @ $35 ea.		2,450	
Other Direct Costs		400	
Process Engineering; Cost Est.			
Senior Project Engineer	120		
Draftsman	10		
TOTAL	460		31,800

[a]All costs include G+A and fee.